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ABSTRACT

A year-long study examined how phonics or whole word instruction affected first graders' progress in reading and spelling words. Subjects, 80 Houston, Texas students of average reading and intellectual abilities from three classrooms receiving phonics instruction and three classrooms receiving whole word instruction, were administered a phonemic segmentation test three times during their first grade year and asked to spell, read aloud, and identify from a word list 60 regular and exception words. Results indicated that: (1) the phonics group read aloud and identified more words correctly than the whole word group; (2) reading groups did not differ in phonemic segmentation or spelling; (3) reading instruction appeared to help children relate their knowledge of regular word spellings to correct oral readings at a faster rate than whole word children's instruction did; and (4) there existed a unidirectional relation between phonemic segmentation and oral reading and a bidirectional relationship between phonemic segmentation and spelling. (Four figures and six tables of data are included; 49 references are attached.) (RS)

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HOW READING INSTRUCTION MEDIATES PROGRESS IN FIRST GRADE READING AND SPELLING

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Abstract

In this year-long investigation we sought to examine how phonics or whole word instruction affected first graders' progress in reading and spelling words. Accordingly, we chose to observe children of average reading and intellectual abilities whose teachers' instructional practices were clearly identifiable as operating at the whole word or phoneme level of analysis. In October, February, and May of the first grade year 80 children from three classrooms receiving phonics instruction and three classrooms receiving whole word instruction were administered a phonemic segmentation test and asked to spell, read aloud, and identify from a word list 60 regular and exception words. Results from repeated measures analyses indicated that the phonics group read aloud ($p < .025$) and identified ($p < .05$) more words correctly than the whole word group, and that reading groups did not differ in phonemic segmentation or spelling ($p > .05$). The results favoring the phonics group that were significant at our criteria of $p < .01$ were interactions of reading instruction with time in the case of spelling and three-way interactions of reading instruction by time by type of word in the case of the two measures of reading. The case for the escalating superiority of phonics instruction on reading and spelling performance was even stronger in the analyses of individual growth. Utilizing an hierarchical linear models approach, we found that reading instruction appeared to help children relate their knowledge of regular word spellings to correct oral readings at a faster rate than whole word children's instruction did. We also found evidence of a uni-directional relation between phonemic segmentation and oral reading and a bi-directional relation between phonemic segmentation and spelling.

The "great debate" over the relative merits of code-emphasis versus meaning-emphasis instruction in beginning reading continues as passionately as ever (Adams, in press; Carbo, 1988, 1989; Chall, 1989a, 1989b). We see the relation between codes and meaning as nonorthogonal in that the teaching of codes need not preclude meaningful context and the stress on meaning need not preclude the teaching of codes (see Stahl & Miller, 1989). We assume that the real debate is between teaching rules for grapheme-phoneme correspondences (i.e., synthetic or analytic phonics) and teaching sight recognition of words (i.e., look-say or whole word). The present investigation was designed to study the changes in how first graders read and spell words as they are exposed to phonics or whole word instruction.

In the past two decades dozens of studies have documented predictable effects of method of reading instruction on first grade readers (see Allington, 1984 for a review). Those in programs emphasizing meaning typically produce errors reflecting sensitivity to contextual constraints, while those in programs emphasizing codes typically produce errors reflecting sensitivity to graphemic cues (Dank, 1977; DeLawter, 1975; Elder, 1971). These relatively "pure" method studies can be contrasted with findings from eclectic, basal approaches where first graders were said to move from a context-dependent stage, to a graphemic processing stage, to a stage where contextual and graphemic cues were integrated (Biemiller, 1970; Weber, 1970). But, as Stanovich (1986) points out, since variability in the ability to use context to facilitate word recognition is so relatively low, context-use may not be a major source of individual differences in reading acquisition. What does emerge from the literature as the source of individual differences in reading ability is rapid, efficient decoding of words (Perfetti, 1985, 1986). When the bottom-up decoding processes that constitute word recognition are deficient, other information, such as context, must be drawn upon. According to an interactive model of reading, the top-down application of contextual information becomes compensatory if the bottom-up decoding skills are inadequate.

Recent research points to phonological awareness as the prime source for individual differences in reading acquisition, where phonological awareness is the cognitive ability to categorize similar sounds and to consciously manipulate phonemes in the spoken language (Bradley & Bryant, 1983, 1985; Lundberg, Frost, & Petersen, 1988; Tunmer, Herriman, & Nesdale, 1988). More specifically, it appears that it is the bootstrapping of phonological awareness on orthographic awareness that produces success in beginning reading (Foorman & Liberman, 1989; Stanovich, 1986). In contrast to this bootstrapping or reciprocal causation model is the view that phonological awareness is the product not cause of reading success (Ehri, 1979, 1983, 1985; Morais, Bertelson, Cary, & Alegria, 1986; Read, Yun-fei, Hong-Yin, & Bao-Qing, 1986). In fact, for Ehri (1989) spelling is a crucial element in the model: Knowledge of a word's spelling is relevant to how a word is read and knowing how to read a word is relevant to segmenting its phonemes. An important objective for the present investigation was to model the relation between phonemic segmentation, oral reading, and spelling. We predicted, in line with Ehri (1989), that only for those children receiving phonics instruction, where segmenting and blending skills were explicitly taught, would spelling predict oral reading which, in turn, would predict phonemic segmentation.

One might well wonder if there are any advantages to whole word instruction. The most obvious advantage lies in the reading of the many words which are exceptions to English spelling patterns. Words such as have, pint, and sword are exceptions to the regular spellings represented by save, tint, and swore (where /w/ is pronounced). Arguably, exception words are most efficiently read by direct visual access to a reader's mental dictionary (the mental lexicon). Whole word instruction should facilitate such direct visual access to meaning, while phonics instruction should delay and possibly distort access because of its emphasis on application of grapheme-phoneme correspondence rules to all words, whether spelled regularly or not. Perfetti, Beck, Bell, and Hughes (1987) have shown that phonics and whole word instruction do mediate pre- and postlexical routes

to word processing. Thus, phonics children should exhibit regularity effects where recognition of regular words is better than recognition of exception words and errors on the reading of exception words reflect over-regularization (e.g., reading pint to rhyme with tint).

Does it necessarily follow, then, that there will be no regularity effect for whole word children? Do we expect them to skip Frith's (1985) alphabetic stage altogether and leap from a logographic strategy of reading words as unanalyzed wholes to an orthographic strategy of reading words through application of knowledge about spelling patterns? No, we expected to see the emergence of an alphabetic strategy in whole word children as their oral reading and spelling errors on regular and exception words became increasingly phonetic across the first grade year. But what we did not expect was for this alphabetic strategy to translate into correct reading and spelling at the same rate nor to the same extent as it did for phonics-instructed children.

Since a regularity effect may be partly an artifact of reading aloud tasks, where the assembly of a phonological code is demanded for output, a non-oral word recognition task was also included. Two forms of the task were constructed, a form with clues and a form without clues, because Goswami (1986) found that clues helped five-year-old non-readers correctly identify targets. In the form with clues, a clue word was presented which was consistent with the beginning of the target (onset) or with the end of the target (rime). The child was asked to find the target from a list of seven alternatives. Alternatives were consistent with initial medial, and/or final letter-sounds of the target. If word recognition is an analogical process (Glushko, 1979, 1981), then the specific word association provided by the clue word might facilitate recognition more for those children receiving whole word instruction than for those children taught the grapheme-phoneme correspondence rules of phonics instruction. On the other hand, when asked to recognize an exception target like warm, phonics children might exhibit sensitivity to medial sounds in their selection of the

alternative worm, while whole word children might stick to a focus on initial and final letter-sounds by selecting whim.

In summary, we conjectured about the way in which first grade reading instruction mediates the relation between phonemic segmentation, oral reading, and spelling, as well as about the way it mediates regularity effects in oral and non-oral word recognition tasks. Specifically, we predicted that:

1. The relation between phonemic segmentation and oral reading will generally be one of reciprocal causation, but, in addition, knowledge of words' spellings will predict accuracy of their oral readings for children receiving phonics instruction.
2. Children receiving phonics and whole word instruction will exhibit regularity effects in oral reading. However, children receiving whole word instruction will not exhibit regularity effects to the same extent nor at the same rate as children receiving phonics instruction.
3. Children receiving whole word instruction will be more accurate than children receiving phonics instruction in a non-oral task where clues are provided. However, analysis of errors on recognizing exception words will reveal phonics children's greater sensitivity to medial sounds.

Method

Subjects

Eighty first graders from three schools in Houston, Texas, representing lower-middle and middle-class populations participated in the study. Forty of the subjects, half male and half female, were in three classrooms in a public school where reading was taught by a whole word approach. The other 40 subjects (half male and half female) were in three classrooms in two parochial schools where reading was taught by a phonics approach. All six teachers were experienced first grade teachers. All six classrooms supplemented basal readers with materials and strategies relevant to a whole word or phonics approach. The teachers delivering whole word instruction copied basal stories and key words onto

tagboard and asked children to read the stories aloud in small groups and visually match the key words with the words in the stories. Children in the phonics classrooms were taught rules for relating graphemes and phonemes. They applied their knowledge of these rules in exercises in a phonics workbook and were expected to "sound out" and blend unknown words.

Spelling was taught slightly differently in the whole word and phonics classrooms. Whole word classrooms used the Stetson Reading-Spelling Approach (Stetson, 1984) where teachers projected a word written on a transparency, pronounced the whole word, pronounced each syllable (or onset-rime), and pronounced each letter-sound. With the projector turned off, students had to name the whole word, its syllables and letter-sounds from memory, and then write the word on paper. Finally, the word was projected again and students corrected their misspellings. In the phonics classrooms the teachers dictated a list of words from the spelling workbook to the students at the beginning of each week. Misspellings were corrected. During the week students wrote these words in the exercises in their workbook. There were also spelling games where the words were spelled orally. In spite of the somewhat more phonetic emphasis to spelling in the whole word classrooms and the somewhat more visual emphasis to spelling in the phonics classrooms, what was common across all six classrooms was that reading and spelling curricula were completely separate. Reading and spelling were taught at different times with different words.

Phonics and whole word classrooms were seen as comparable in ethnic diversity, age, reading achievement, and intelligence. Thirty-five percent of subjects in the whole word group were ethnic minorities and 30% of subjects in the phonics group were ethnic minorities. Subjects identified as ESL (English as a second language) were not included in the study. Mean differences in age in months, raw scores on the Gates-MacGinitie, Basic R (MacGinitie, 1978), and raw scores on the Peabody Picture Vocabulary Test (PPVT), Form L-Revised (Dunn & Dunn, 1981) were insignificant ($p > .05$). Means, ranges, and normative equivalencies are given in Table 1.

Insert Table 1 about here

Materials

Sixty single-syllable, real English words were selected by the authors for the reading and spelling measures: 78% had four letters; 17% had 5 letters; and 5% had 3 or 6 letters. Of the 60 words, 40 had regular spelling patterns and 20 had exception spelling patterns. There was a consistent level of word frequency for the 60 words (as assessed by reference to Carroll, Davies, and Richman (1971) and by pilot-testing the words with 6- and 7-year-olds). Only one of the words (i.e., last) was included in the list of first grade words to be taught. All other words were at the second grade level or higher in the Harcourt Brace Jovanovich series used by the whole word classrooms and the Scott Foresman series used by the phonics classrooms.

Procedure

Subjects were administered the Gates-MacGinitie Reading Test and the PPVT in October only. Spelling and reading tests and the phonemic segmentation test (Rosner, 1979) were administered in October, February, and May.

The spelling test consisted of five groups of 12 words each. Each group consisted of 8 randomly selected regular words and 4 randomly selected exception words, presented in sentences written by the authors. The teachers administered the spelling test over the period of a week, during language arts time, one group of 12 words per day.

After the Gates-MacGinitie Reading Test and the spelling test were completed, children were individually administered by an experimenter, the PPVT (October only), an untimed oral reading test of the 60 words, a non-oral recognition test of the 60 words, and Rosner's (1979) Test of Auditory Analysis Skills (TAAS). Oral reading was assessed by individually presenting, in two random orders, the 60 words printed individually on 3 x 5 cards. Responses were audio-taped.

The recognition test consisted of 60 lists of seven words, either with (clue condition) or without (no clue condition) a clue word typed in bold at the top of each list. (In addition, two preliminary practice lists were administered.) In the no clue condition the experimenter stated the word, pointed to the list of seven words, and asked the child to mark the number next to the word the experimenter had said. In the clue condition the experimenter pointed to the bold-typed word, pronounced it (pausing for the child to pronounce it too), and then pointed to the list of seven words and asked the child to mark the number next to the target word. Alternatives in each list were consistent with initial and/or final letter-sounds of the clue or target. For example, "This word is **write**. Which word is 'rack'?" (from the list kite, wrote, crate, wreck, rook, rack, and wild). Wild, kite, crate, and wrote relate to initial and/or final letter-sounds of the clue "write." Rook, wreck, and the correct choice, rack, relate to the initial and/or final letter-sounds of the target. In this example the clue is an exception word and the target is a regular word with similar beginning sounds (onsets). In other test items clues and targets have the same ending sounds (rimes). The first 20 items of the recognition test had regular clues and regular targets. In the next 40 items half had regular clues and exception targets and half had exception clues and regular targets. Two random orders of these latter kinds of items were obtained, one in which regular clues and exception targets came first and one in which exception clues and regular targets came first. For both random orders the test began with the 20 items with regular clues and regular targets.

The final test administered was Rosner's (1979) Test of Auditory Analysis Skills (TAAS). This 13-item test requires deletion of initial, medial, and final sounds, first at the syllable level, then at the phoneme level. For example, "Say picnic, now say it again without pic (nic)." Other items are: coat-oat and wrote-row; play-lay and stale-sale.

Scoring of Reading and Spelling Measures

Accuracy scores for spelling, oral reading, and word recognition were derived by computing numbers of correct responses for regular words and for exception words.

Spelling and oral reading errors were categorized by the experimenters as phonetic or non-phonetic, in similar fashion to Mitterer's (1982) coding of conservative and liberal. In phonetic errors every letter is given a plausible sound value, even though some may be incorrect. For example, the spellings krom and fas are phonetic errors for the exception words chrome and phase and lim and rat are phonetic misspellings for the regular words lime and rate. No sounds have been omitted and no extraneous sounds have been included. In contrast, kut for putt, cal for shall and bolw for bowl are non-phonetic errors. Non-responses on the oral reading test were coded as nonphonetic since frequencies were low and similar across methods of reading instruction (i.e., from 7.8% to 7.6% to 2.4% for whole word children across the year and 6.5% to 2.2% to 1% for phonics children). To check reliability of scoring, approximately 10% of the oral reading and spelling data were rescored by the authors. Agreement was virtually 100%.

Errors on the reading recognition test were categorized in terms of their proximity to the target, far, medium, and near. Far errors shared beginning sounds in the onset condition and ending sounds in the rime condition. Medium errors shared beginning and ending sounds in both conditions. Near errors were like medium errors except that they shared similar medial sounds as well. So in the write-rack example given above, round and wrote are far errors, rook is a medium error, and wreck is a near error. Take the example of the regular clue and the exception target cut-putt. Here glut and mutt are far errors, pit is a medium error, and put is a near error. Put represents the regularized spelling pattern for putt, as evidenced by the regular clue, cut.

Results

Two different statistical approaches were used to analyze the number of correct responses over the course of the first grade year on the tests of phoneme segmentation, spelling, oral reading, and recognition reading. The two approaches were the multivariate approach to repeated measures analysis of variance and hierarchical linear models. For the repeated measures approach the level of significance was set at .01 for each dependent

variable because of the inter-relatedness of the four dependent variables. Errors on reading and spelling tests were analyzed descriptively to determine relative shifts in number of nonphonetic and phonetic errors over the course of the first grade year, as well as with repeated measures to test specific hypotheses.

Multivariate analyses of variance with repeated measures were useful in addressing questions related to instructional group differences in performance on regular and exception words over time. Specifically, over the course of the first grade year, to what extent would children receiving phonics instruction be more accurate in their reading of regular words than children receiving whole word instruction? What about exception words? To what extent would phonics children also exhibit a greater tendency to regularize exception words when reading aloud and to exhibit sensitivity to medial sounds when asked to recognize an exception word out of a list of similar words? To what extent would phonics children's spelling performance be better than whole word children's?

In contrast, hierarchical linear models (HLM) provided a powerful set of techniques for researching individual change (Bryk & Raudenbush, 1987; Rogosa & Willet, 1985). The three time points of this study were considered nested within each subject.[1] At the within-subjects stage, individual growth trajectories were determined for each subject. At the between-subjects stage, each subject's growth trajectory was represented as a set of outcome variables to be explained by such subject characteristics as age at the beginning of the study, PPVT-R score, classroom membership and reading instruction. One focus for the study was status at the end of the year. Consequently, the central question was what beginning characteristics of first graders best predict performance in reading and spelling at the end of the year? For each of the tests administered, HLM provided a description of the structure of the mean growth trajectory and estimated the extent of individual variation around mean growth. Additionally, reliabilities of the measures for studying status and change were calculated. The correlation between final status and rate of change was

estimated and the effect of background and instructional variables on rate of change was assessed.

Repeated Measures Analyses

Separate, mixed model analyses of variance with repeated measures were used to analyze accuracy and errors on spelling and reading tests and phonemic segmentation scores. Means for these measures are presented in Table 2.

Insert Table 2 about here

Phonemic segmentation. The analysis of scores on Rosner's Test of Auditory Analysis Skills included Method of Reading Instruction as a between-subjects factor and Time as a within-subjects factor. Only Time was significant, $F(2,73) = 33.23$, $p < .001$.

Spelling. The number of words spelled correctly was analyzed with Method of Reading Instruction as a between-subjects factor and Word Type (regular or exception) and Time as within-subject factors. There was a significant interaction of Time with Reading Instruction, $F(2,77) = 7.02$, $p < .01$. In this interaction the phonics group's mean scores increased 6.67 words between October and February and 4.76 words between February and May. The corresponding increases for the whole word group were 4.5 words and 2.7 words. The smaller change from February to May may have been due in part to the shorter nature of this time interval (i.e., 3 months) compared to October to February (i.e., 4 months). The actual rate of change in any particular group was approximately equal over the two time intervals. Spelling errors became increasingly phonetic across the first grade year for both methods of reading instruction. The only time when the mean number of nonphonetic errors exceeded that of phonetic errors was in October when whole word subjects misspelled regular words.

Oral reading. The number of words read aloud correctly was analyzed with Method of Reading Instruction as a between-subjects variable and Word Type and Time as within-subject variables. The main effect of reading instruction ($p = .022$) was not significant at the designated level ($p < .01$). However, there was an interaction of Reading Instruction and Time, $F(2,77) = 10.87$, $p < .001$. There was also a significant interaction of Reading Instruction and Time with Type of Word, $F(2,77) = 9.89$, $p < .001$. The phonics group improved dramatically on regular words across time, from 32% to 66% to 80%, compared with 30% to 48% to 60% for the whole word group (percentages derived from means of Table 2). The rate of improvement was not as dramatic on exception words for either group; nonetheless, it was still greater for the phonics group: 20% to 39% to 50% compared with 17% to 31% to 35% for the whole word group.

The whole word group's relative lack of improvement on exception words from February to May is partly explained in the analysis of errors. To examine errors in reading aloud exception words, a mixed model of analysis of variance was done with Method of Reading Instruction as a between-subjects factor and Error Type and Time as within-subjects factors. There were significant interactions of Reading Instruction by Time, $F(2,77) = 5.55$, $p < .01$, and Time by Error, $F(2,77) = 26.02$, $p < .001$. The first interaction is explained by the fact that the average number of errors on exception words decreased from 7.09 to 5.84 to 4.77 across the year for phonics children, while the initial decrease was followed by an increase for whole word children (i.e., 7.31 to 5.99 to 6.26). The Time by Error interaction can be explained by noting that means for phonetic errors increased across the year from 4.56 to 5.22 to 5.45 and that means for nonphonetic errors decreased from 9.83 to 6.6 to 5.59. In other words, in October errors on reading aloud exception words were predominantly nonphonetic but by May they were equally likely to be phonetic as well as non-phonetic.

Even though whole word children were not producing more correct pronunciations of exception words at the end of the year as phonics children were, at least their

pronunciations appeared to be becoming less nonphonetic. Specifically, whole word children's means for nonphonetic errors decreased from 10.42 to 7.47 to 7.10 across the year, while their means for phonetic errors rose from 4.20 to 4.5 to 5.42. The corresponding means for the phonics children were 9.25 to 5.72 to 4.07 and 4.92 to 5.95 to 5.47. To investigate whether the time effect on error types was significantly different for whole word subjects, a within-subjects analysis was performed. This analysis used a Bonferroni adjusted p-value based on the number of ways of breaking down the interaction of time and error type within group. Specifically, we set alpha for the time by error type within group interaction at .05/2 = .025, then observed a significant Time by Error interaction, $F(2,38) = 9.31$, $p < .001$. Next, because we had specific interest in the linear and quadratic effects of time, we treated each of these polynomial contrasts as a separate effect and further divided alpha by 2, that is, alpha = .025/2 = .0125 for testing single degree of freedom effects of time by error type. The significant Linear by Error interaction, $F(1,39) = 18.08$, $p < .001$ met our criteria. Finally, we looked at the significance of the time effect within each error type. Using alpha = .0125/2 = .0062 as our criteria, we found the Time effect significant only for nonphonetic errors, $F(2,38) = 10.22$, $p < .001$. The univariate test of repeated measures indicated a significant linear trend. In other words, whole word children did indeed significantly decrease the number of nonphonetic errors they made across the year when reading aloud exception words. However, their increase in phonetic errors was not significant.

Word recognition. By the end of the year most children achieved 100% accuracy on the first 20 items of the test, items with regular clues and regular targets. Therefore, analyses of results considered only the 20 items with exception clues and regular targets and the 20 items with regular clues and exception targets. Between subjects factors were Method of Reading Instruction and Nature of Clue Condition. Within-subjects factors were Word Type, Word Part (i.e., onset/rime), and Time. First, both reading groups were more accurate in the no-clue condition, especially when the targets were exception words,

$F(1,76) = 7.98$, $p < .01$. Secondly, both groups were more accurate in items with shared onsets than with shared rimes, especially over time when targets were regular, $F(2,75) = 10.08$, $p < .001$. Third, unlike the oral reading results, there was no main effect of reading instruction ($p = .04$). However, the Reading Instruction by Time by Word Type interaction approached the designated level of significance ($p < .01$), $F(2,75) = 4.32$, $p = .017$. Whole word children improved only marginally in recognizing exception words between February and May (i.e., 44% to 48%), while phonics children improved more (i.e., 48% to 62%).

To determine whether phonics children were more sensitive to medial sounds than whole word children, reading groups were compared on the number of near errors made in recognizing the ten exception words in the rime condition. Over time the mean number of medium errors decreased for both reading groups (i.e., 1.30 to .92 to .47 for whole word children and .72 to .50 to .42 for phonics children). But means for near errors decreased over time only for phonics children (i.e., 5.25 to 5.22 to 4.15). Whole word children's means were U-shaped (i.e., 4.87 to 4.57 to 5.15). This interaction of Method of Reading Instruction and Time did indeed prove significant, $F(2,75) = 7.10$, $p < .001$. Hence, changes over the year in mean number of near errors on exception words in the rime condition differed significantly for whole word and phonics instructional groups.

To better understand these results, consider the exception target putt, presented to half of the subjects with the regular clue cut. Words in the response array were cord, glut, mutt, cot, pit, put, and putt. Results indicated that, unlike whole word children, phonics children were never particularly interested in the first and final letter strategy represented by pit. The strategy of preference for phonics children included consideration of medial sounds. Hence, phonics children selected put just over 50% of the time in October and February and just under 50% of the time in May. Meanwhile their accuracy rates increased from 32.5% to 40.7% to 52.2% (see means of Table 2). Whole word children did not achieve the 50% mark on put until the end of the year. Meanwhile, their accuracy rates,

which had been similar to that of the phonics subjects for October and February (i.e., 30.5% and 40.2%), made little gain in May (i.e., 41.7%). So it appears that phonics children's greater sensitivity to medial sounds allowed them to move more quickly into accurate identification of words with irregular spellings.

Hierarchical Linear Models

Separate individual growth models were examined for number correct on spelling, oral reading and word recognition, and phonemic segmentation tests. In each case the growth rate was centered around the final data collection time. The within-subjects models of spelling and reading varied depending on the outcome measure, but always included time and type of word (regular or exception) and whether time effects differed for regular and exception words. The between-subjects equation for the intercept included initial status (i.e., October test score) as well as subject characteristics of age in months, PPVT-R raw score, class membership, and reading instruction. Initial status was not included as a variable in the between-subjects equations for the slopes. In addition, spelling variables were included in all the between-subjects equations in the oral reading model and vice versa. Finally, clue condition was included as a between-subjects variable in the word recognition model. These variables were included in the initial models, however we present here only the final models with the variables that were statistically significant or approached statistical significance.

Spelling

The linear growth model which best described a first grader's growth in spelling was: $Y_{it} = \pi_{0i} + \pi_{1i}\,(\text{Time}_{it}) + \pi_{2i}\,(\text{Word Type}) + \pi_{3i}\,(\text{Word Type} \times \text{Time}_{it})$ where π_{0i} represents expected spelling level of the child at the end of the first grade year, π_{1i} represents the constant rate of change in a child's spelling over the first grade year, holding constant the effect of word type. The remaining terms represent differential effects for regular and exception words. Word type is a dichotomous variable coded 1 for exception words and -1 for regular words. Hence, π_{2i} represents the effect of word type on expected

mean spelling for child i at the end of first grade, whereas π_{3i} represents the effect of word type on the constant rate of change. Consequently, this model translates into the following model for exception words:

(1.e) $$Y_{it} = (\pi_{0i} + \pi_{2i}) + (\pi_{1i} + \pi_{3i})\ (Time_{it})$$

and the following model for regular words

(1.r) $$Y_{it} = (\pi_{0i} - \pi_{2i}) + (\pi_{1i} - \pi_{3i})\ (Time_{it})$$

Three whole word subjects were dropped from the analysis because their low initial scores remained perfectly constant over the year. Their estimated growth rates were, therefore, extreme in relation to the rest of the sample. For the remaining 77 subjects, estimates of the parameters in the models were:

$$\hat{\pi}_{0i} = 6.68 + (-1.68)\ (\text{Reading instruction}) + (.389)\ (\text{Initial reading status/Regulars}) + (.178)\ (\text{initial phonemic segmentation status})$$

$$\hat{\pi}_{1i} = [1.052 + (-.290)\ (\text{Reading instruction}) + (.023)\ (\text{Initial reading status/Regulars})]\ (Time_{it})$$

$$\hat{\pi}_{2i} = -5.434 + (.918)\ (\text{Reading instruction}) + (-.195)\ (\text{Initial reading status/Regulars}) + (-.140)\ (\text{initial phonemic segmentation status})$$

$$\hat{\pi}_{3i} = [-.817 + (.155)\ (\text{Reading instruction})]\ (Time_{it})$$

These equations indicate that within the models for exception and regular words were separate models for the phonics and whole word methods of reading instruction. The effects and the corresponding coefficients for these four models of individual growth in spelling are summarized in Table 3.

Insert Table 3 about here

In Table 3 we see the constant positive effect that reading aloud regular words had on growth rate in spelling. For every one-word increase in reading aloud regular words at the beginning of the year, there was a .023-word increase in the constant rate of change in

spelling scores. However, initial status on reading aloud regular words differentially affected the final spelling status on regular and exception words. Specifically, for every one-word increase in reading aloud regular words at the beginning of the year, there was a .584-word increase in spelling regular words at the end of the year, compared to a .194-word increase in spelling exception words at the end of the year. The same differential effect of word type was evident in the effect of initial scores on the phonemic segmentation test. For every one-point increase in phonemic segmentation scores at the beginning of the year, there was a .318-word increase in the number of regular words spelled correctly at the end of the year, compared to a .038-word increase in the number of exception words spelled correctly at the end of the year. Finally, at the bottom of Table 3 we note the differential effects of word type and reading instruction on growth rate in spelling. Improvement in spelling exception words was slower than improvement in spelling regular words, in spite of method of reading instruction. But, importantly, phonics-instructed children improved at almost twice the rate of whole word-instructed children in spelling regular words (2.314 vs. 1.424) and at almost three times the rate in spelling exception words (.370 vs. .100).

Estimated spelling scores were obtained by substituting into equations (1.e) and 1.r) individuals' Empirical Bayes (EB) estimates for π_{0i}, π_{1i}, π_{2i}, and π_{3i}. Scores for the 77 out of the 80 children with adequate data for computation have been plotted in Figure 1 for regular and exception words, with individuals coded according to method of reading instruction.

Insert Figure 1 about here

There are two striking characteristics of Figure 1. First, whole word children, represented by solid lines, are at the top and bottom of the plots for both regular and exception words. Second, with respect to exception words, whole word children exhibited

greater variability in growth rate than phonics children did. That is, the whole word children at the top of the graph exhibited impressive positive gains, while the whole word children at the bottom of the graph exhibited negative gains. Remember that Figure 1 depicts 77 regression lines, each of which estimates the extent of individual variation around mean growth. These lines are not plots of actual scores; rather, they are plots of predicted scores, predicted by the available characteristics of first graders that best describe the structure of individual growth in spelling. According to the model presented above, the best predictors of growth in spelling were method of reading instruction and October scores on reading aloud regular words, phonemic segmentation, and the type of word being spelled.

This individual growth model for spelling explained 70.21%, 59.47%, 44.03%, and 21.35% of parameter variance in final status, differential final status due to word type, growth rate, and differential growth rate due to word type, respectively. Reliability estimates were high for final status word type, and growth rate (i.e., .86, .75, and .69, respectively), and moderate for word type x growth rate (i.e., .53). All chi-square statistics were significant (see Table 4). Also, the correlation between final status and growth rate was high (i.e., .91). The significant chi-square statistics indicate that there was still some remaining variation in the growth rate and final status of first graders' spelling scores as well as in differences in spelling performance due to degree of regularity of the words to be spelled. Possibly some of the variation remaining in final status and growth rate has to do with handwriting skill. That is, in the spelling test students had to write down the words dictated to them and we observed some children concentrating on the proper formation of letters. Clearly, in addition to the phonological component that we have accounted for, there is a motor component to such a test for which we have not accounted.

Insert Table 4 about here

Oral reading. The hierarchical linear model that best described individual growth in oral reading was:

(2) $Y_{it} = \pi_{0i} + \pi_{1i}\,(Time_{it}) + \pi_{2i}\,(Word\ Type) + \pi_{3i}\,(Word\ Type \times Time_{it})$

which says that performance for subject i at time t is a function of the individual's age at time t and whether the word being read has a regular or exceptional spelling. This model translates into the following model for exception words:

(2.e) $Y_{it} = (\pi_{0i} + \pi_{2i}) + (\pi_{1i} + \pi_{3i})\,(Time_{it})$

and the following model for regular words:

(2.r) $Y_{it} = (\pi_{0i} - \pi_{2i}) + (\pi_{1i} - \pi_{3i})\,(Time_{it})$

For the current data, estimates of the parameters in these models were:

$\hat{\pi}_{0i}$ = 10.86 + (-2.99) (Reading instruction) + (.823) (Initial spelling status/Regulars) + (.387) (initial phonemic segmentation status)

$\hat{\pi}_{1i}$ = [1.47 + (-.350) (Reading instruction)] ($Time_{it}$)

$\hat{\pi}_{2i}$ = -5.95 + (1.46) (Reading instruction) + (-.416) (Initial spelling status/Regulars) + (-.198) (initial phonemic segmentation status)

$\hat{\pi}_{3i}$ = [-.774 + (.171) (Reading instruction)] ($Time_{it}$)

It can be seen from the models for the parameters that within the models for exception and regular words were separate models for each method of reading instruction. The effects and the corresponding coefficients for these four models of individual growth in oral reading are summarized in Table 5. The fixed effects are reading instruction, initial status on phonemic segmentation and spelling regular words. The random effects are the intercept (i.e., the expected value at final status, holding all other significant effects constant) and time (i.e., growth rate), and the differential word type effects. We note in Table 5 that the effect of phonemic segmentation and of initial status in spelling regular

words varied depending on word type. Holdling all other effects constant, for every one-point increase in phonemic segmentation scores at the beginning of the year, there was a .585-word increase in number of regular words read aloud correctly at the end of the year compared to a .189-word increase in the number of exception words read aloud correctly at the end of the year. Similarly, for every one-word increase in number of regular words spelled correctly at the beginning of the year, there was a 1.239-word increase in reading aloud regular words compared to a .407-word increase in reading aloud exception words at the end of the year, again holding all other effects constant. We also note in Table 5 the differential effects of word type and reading instruction on growth rates in oral reading. Within regular and exception words, phonics children improved in oral reading at a faster rate than whole word children (i.e., 2.765 vs. 1.723 for regular words and .875 vs. .517 for exception words).

Insert Table 5 about here

Figure 2 provides a comparison of the distribution of growth rate estimates for reading aloud exception words (top) and regular words (bottom). The points along the horizontal (x) axis break off certain percentages of the data. For example, .25 to .75 represents the middle fiftieth percentile of the data. The points along the vertical (y) axis show estimated growth rate in words per month associated with that particular percentile. Consequently, differences in elevation of the two lines reflect the difference in growth rates between the two groups at a given percentile. For example, on regular words the median growth rate (x = .5) for whole word children was approximately 1.8 words per month (y = 1.8), whereas the median growth rate for phonics children was somewhat higher, approximately 2.5 words per month (y = 2.5).

Insert Figure 2 about here

Whereas elevation differences reflect group differences in growth rates at fixed points in the distributions, the slope of the line over any given range of percentiles of Figure 2 reflects how variable the growth rates were at that range of the distribution. Put another way, flatness in the line reflects a high concentration of data at that point on the y-axis. Consequently, group differences in slope reflect group differences in the variability in growth rates over some range of the distribution. For example, between the minimum value and the twenty-fifth percentile on regular words there was greater variability in the phonics group compared to the whole word group. The same was true in the upper quartile of the data, but to a lesser degree. However, some of the whole word children exhibited steady growth. In fact, the whole word child with the greatest growth was at approximately the eighty-eighth percentile of the phonics group on regular words. On exception words the slopes of the quartile lines were fairly similar for both reading groups throughout the distribution. But, again, the phonics group had slightly more variability in both tails of the distribution.

Finally, we turn to the issues of explanatory power and reliability of this individual growth model for oral reading. Reliabilities and chi-square statistics for the significant effects are provided in Table 4. Reliability coefficients are strong, ranging from a low of .57 for the interaction of word type and time to a high of .91 for final status. All chi-square statistics are significant, indicating significant remaining variation in the parameters describing change in oral reading scores. Finally, the explanatory power of the model is variable, with the percentage of parameter variance explained in final status, word type, word type by growth rate, and growth rate being 60.15%, 45.60%, 16.86%, and 25.93%, respectively. The correlation between final status and growth rate was strong (i.e., .79).

Word Recognition. The hierarchical linear model that best described individual growth in word recognition was:

(3) $Y_{it} = \pi_{0i} + \pi_{1i}\,(Time_{it}) + \pi_{2i}\,(Word\ type) + \pi_{3i}\,(Word\ part)$

where,

$\hat{\pi}_{0i} = 10.67 + (-.078)$ (Initial age) + (-.377) (Reading instruction) +
(.124) (Initial oral reading status/Regulars) +
(.114) (Initial phonemic segmentation status)

$\hat{\pi}_{1i} = [1.242 + (-.009)$ (Initial age) + (-.053) (Reading instruction)
+ (-.045) (Initial onset-regular) + (-.052) (Initial onset-exception)
+ (.015) (Initial oral reading status/Regulars) + (.016)
(Initial phonemic segmentation status)] $(Time_{it})$

$\hat{\pi}_{2i} = -1.207$ (Word Type)

$\hat{\pi}_{3i} = .216 + (.026)$ (Initial oral reading status/Regulars)

As in the oral reading model, there are separate models for regular and exception words, indicated by the equations (3.r) and (3.e). But here the models embedded within word type are models for word part (i.e., onset vs. rime or (3.ro) vs. (3.rr) and (3.eo) vs. (3.er)). Accordingly,

(3.r) The models for regular words are:

(3.ro) Onset: $Y_{it} = \pi_{0i} + \pi_{1i}\,(Time_{it}) - \pi_{2i} + \pi_{3i}$

(3.rr) Rime: $Y_{it} + \pi_{0i} + \pi_{1i}\,(Time_{it}) - \pi_{2i} - \pi_{3i}$

(3.e) The models for exception words are:

(3.eo) Onset: $Y_{it} = \pi_{0i} + \pi_{1i}\,(Time_{it}) + \pi_{2i} + \pi_{3i}$

(3.er) Rime: $Y_{it} + \pi_{0i} + \pi_{1i}\,(Time_{it}) + \pi_{2i} - \pi_{3i}$

The coefficients for the significant effects of this individual growth model of word recognition are given in Table 6. In Table 6 we notice the constant positive effect of initial phonemic segmentation scores. Holding all other effects constant, a one-word increase in October phonemic segmentation scores was associated with a .114-word increase in May

word recognition scores and a .016-word increase in growth rate. We also notice the constant negative effect of initial age, meaning that, holding all other effects constant, children older than average in October had May word recognition scores that were lower and growth rates that were lower. The accuracy with which regular words were read aloud in October positively affected growth rate (by .015-words) and positively, but differentially, affected final status. Specifically, for every additional regular word read aloud correctly in October, there was a .15-word increase in recognizing words embedded in lists of words with shared onsets but only a .098-word increase in recognizing words embedded in lists of words with shared rimes. This differential effect of onset and rime conditions was also apparent in the finding that for every additional regular and exception word recognized in the onset condition in October, there was a .045-word and .052-word decrease, respectively, in growth rate.

Insert Table 6 about here

Reading instruction affected growth rate and final status. The negative coefficient for the effect of reading instruction on time indicates that children receiving phonics instruction improved in word recognition at a slower rate than children receiving whole word instruction. In spite of this slower growth rate, phonics children had significantly higher performance in May ($p = .004$). We see from the top line of Table 6 that final status in May was also affected by word type and word part, in that more regular words were recognized than exception words, and more under onset conditions as compared to rime conditions. But the effect of reading instruction was over and above these linguistic effects of the stimuli.

The explanatory power of this model of word recognition is strong for final status (i.e., 73%). However, the percentages of parameter variance explained for word type, word part, and growth rate were low (i.e., 6.6%, 19.27%, and 4.85%, respectively).

Reliability coefficients were high for final status (i.e., .76) and moderate for word type, word part, and growth rate (i.e., .55, .45, .50, respectively). Chi-square statistics were significant in all cases (see Table 4). In other words, first graders did vary significantly in word recognition in terms of final scores, rate of change and effects of linguistic features of words, and significant variability in these parameters remains unexplained. The variables available for analysis predicted variability well for final status but much less well for growth rate, word type, and word part. All first graders found exception words more difficult than regular words and, within word types, rimes more difficult than onsets. Therefore, it would seem that variability in these effects might be due to word-level linguistic features such as consistency and frequency. Finally, in spite of the remaining variation in growth rate, the correlation between growth rate and final status was very high (i.e., .93).

Phonemic segmentation. Preliminary statistical analyses revealed that the ceiling of the phonemic segmentation test was too low at the final point of data collection. Hence, growth estimates were not reliable for all 80 subjects.

Since initial phonemic segmentation scores had constant positive effects in the models of spelling, oral reading, and word recognition, and the majority of children did exhibit improvement in segmenting sounds across the year, we wanted to find some way to assess correlates of change in phonemic segmentation. First, we plotted children's October scores against the difference between their May and October scores. This plot is presented in Figure 3, with a little random noise introduced to eliminate overplotting, a technique known as jittering (Chambers, Cleveland, Kleiner, & Tukey, 1983).

Insert Figure 3 about here

In Figure 3 we notice a cluster of dots in the bottom righthand side with initial scores greater than 9 and very small change scores (with some being negative). On the

other hand, we notice a cluster of dots in the middle and top left with moderate or low initial scores and moderate or high change scores. For the HLM analysis, we included only those subjects who actually had an opportunity to improve on the test, that is, children with initial phonemic segmentation scores less than or equal to 9. Out of the 80 children, 55 qualified for the analysis. For these 55 children, the hierarchical linear model that best described individual growth in phonemic segmentation was:

$$Y_{it} = \pi_{0i} + \pi_{1i} \text{ (Time}_{it})$$

where,

$$\hat{\pi}_{0i} = 8.54 + (.247) \text{ (Initial spelling status/Regulars)}$$

$$\hat{\pi}_{1i} = [1.17 + (-.135) \text{ (Initial phonemic segmentation status)} + (.034) \text{ (Initial spelling status/Regulars)}] \text{ (Time}_{it})$$

Immediately one notes the presence of spelling in this model and the lack of oral reading. For every additional regular word spelled correctly in October, the growth rate and May scores in phonemic segmentation increased .034-points and .247-points, respectively, holding all other effects constant. The only other effect was initial status on phonemic segmentation. Not surprising, the coefficient here was negative. For every one-point increase in phonemic segmentation scores at the beginning of the year, growth rate decreased by .135-points, holding all other effects constant. At the same time, the correlation between final status and growth rate was nearly 100% (i.e., .9979), which partially reflects the short time frame of the study, the process of selecting subjects for inclusion in this analysis, and the restricted ceiling on the test.

For these 55 children who exhibited growth in phonemic segmentation across the year there was no significant effect of reading instruction on growth rate. Yet when we compare distributions of growth rate estimates for phonemic segmentation in Figure 4, we notice differing slopes in the bottom and top tails of the data. Both reading groups had one subject with negative growth, that is, with less than 0 words segmented correctly per month. Between these negative values and the twentieth percentile there is greater

variability in the whole word group compared to the phonics group. There is also more variability in growth rate for the whole word group's top performer compared to the phonics group's. In general, we conclude that the whole word group grew at a faster rate in phonemic segmentation than the phonics groups, keeping in mind that, on the average, whole word subjects started a little lower than phonics subjects (see Table 2).

Insert Figure 4 about here

The explanatory power of this model of phonemic segmentation is weak for final status (i.e., 9.21%) and moderate for growth rate (i.e., 34.06%). As can be seen from Table 4, reliability coefficients were high (i.e., .90 and .75, respectively) and chi-square statistics were significant. The remaining variation is particularly problematic in the case of final status, where the R^2 is so low. What this suggests is that for these 55 children who exhibited reliable growth in phonemic segmentation across the first grade year, their May scores were not adequately predicted by the oral reading and spelling measures used here.

Remember that initial phonemic segmentation scores had positive effects in the models of spelling, oral reading, and word recognition, and that the majority of children did exhibit improvement in segmenting sounds across the year. In this investigation it appears to be the early acquisition of skill in segmenting sounds that serves to trigger reading and spelling performance in first grade. But we cannot rule out subtle influences of subsequent improvement in segmentation skills. Accordingly, we decided to reconsider the HLM models for spelling and oral reading for the 55 subjects who we felt were capable of demonstrating reliable gains in segmentation skill given the test's inadequate ceiling, that is, the ones who had initial scores less than 9 (see Figure 3). For these subjects we developed a score reflecting the percentage of possible gain actually attained. This score was calculated by taking the difference between a child's May and October scores and dividing it by the maximum score minus the October score (i.e., (May-October)/(13-October)). The

correlation between these subjects' percentage gain scores and initial scores was low and insignificant ($r = -.11$, $p > .05$); therefore, we were assured we had a piece of information reflecting gain in segmentation skill that was not redundant with initial status in phonemic segmentation and that could be added to the models of reading and spelling.

For these 55 subjects, we added percentage gain in phonemic segmentation scores to each component of the hierarchical linear models that had best described individual growth in spelling and oral reading for all 80 subjects. We deleted initial status on phonemic segmentation from the models to increase power. The important finding was that with oral reading as the outcome measure, percentage gain in phonemic segmentation contributed only marginally (at $p = .099$) to the slope of word type, holding constant significant effects due to reading instruction and initial status on spelling regular words. However, with spelling as the outcome measure, percentage gain in phonemic segmentation contributed significantly to all stages of the model. It contributed to final status ($p = .026$), growth rate ($p = .033$), and word type ($p = .024$), holding constant in each case effects due to reading instruction and initial status on reading aloud regular words; it also contributed to the interaction of word type with growth rate ($p = .026$), controlling for reading instruction.

In both the case of oral reading and of spelling, the coefficients were negative for effects involving word type. What this means is that gains in phonemic segmentation were associated with reductions in the difference between regular and exception words. This information, coupled with the positive contribution segmentation made to final status and growth rate in spelling, suggests that improvement in segmenting sounds across the first grade aids in acquiring the more difficult aspects of the alphabetic principle. What was difficult for these first graders was exception words relative to regular words and spelling relative to oral reading. Spelling requires production of graphemes which represent phonemes derived from segmenting words stored in memory. Until an individual knows how to spell a word and can work off an iconic image stored in memory, skill in phonemic

segmentation would seem relevant to spelling. However, in oral reading the memory demand is gone and segmentation does not have to be done at the level of individual graphemes. Yet those who gained in segmentation skill were the ones who were able to reduce the gap between improvement in regular words relative to improvement in exception words. Their tendency to regularize exception words diminished as they recognized when to abandon a letter-by-letter strategy. In short, with continued growth in phonemic segmentation comes refinement in alphabetic understanding toward a recognition of relevant orthographic patterns.

Important as these results sound, conclusions can only be tentative, given the limitations of such analyses. First, the 25 subjects excluded from these analyses because of high initial phonemic segmentation scores were just those subjects most likely to show improvement in reading and spelling. Second, by omitting subjects, power was reduced. Third, because of the restricted range of the phonemic segmentation test, variability in percentage gain was reduced.

Discussion

In this year-long investigation we sought to examine <u>how</u> phonics or whole word instruction affected first graders' progress in reading and spelling words. Accordingly, we chose to observe children of average reading and intellectual abilities whose teachers' instructional practices were clearly identifiable as operating at the whole word or phoneme level of analysis. We assumed these instructional approaches interacted with a natural developmental progression of: (1) reading words as unanalyzed wholes according to a logographic strategy; to (2) reading words through application of rules relating graphemes and phonemes according to an alphabetic strategy; to (3) reading words through application of knowledge about spelling patterns according to an orthographic strategy. To capture the richness of individual diversity in movement through these stages, we attempted to model individual growth as well as to analyze the extent to which reading instruction influenced average reading and spelling performance.

The Relation Between Phonemic Segmentation, Reading, and Spelling

Based on previous research (Foorman & Liberman, 1989; Stanovich, 1986), we assumed that phonological awareness bootstrapped on orthographic awareness to produce successful beginning reading. Specifically, we assumed that the relation between our measures of phonemic segmentation and oral reading would be one of reciprocal causation, meaning that skill in segmenting spoken words into phonemes would transfer to skill in reading words aloud and that skill in reading words aloud would transfer to skill in segmenting words into phonemes. Our investigation attempted to probe the nature of this reciprocally causal pathway. Influenced by Ehri's (1989) work that knowledge of a word's spelling is relevant to how a word is read, we reasoned that the causal pathway between phonemic segmentation and successful reading was lined with orthographic images of how words are spelled. We predicted that the segmenting and blending practice inherent in phonics instruction would enable phonics-instructed children to transfer knowledge of a word's spelling to that same word's reading.

Results from repeated measures analyses were straight-forward but limited. Phonics children's oral reading was more accurate than whole word children's ($p < .025$) and reading groups did not differ in phonemic segmentation or spelling ($p > .05$). The hierarchical linear models (HLM) approach allowed us to examine individual growth and to probe into these variables' inter-relation by entering them into each other's model. First, is there any evidence that the relation between phonemic segmentation and oral reading is one of reciprocal causation? With respect to these measures, the answer is: No. Initial status on phonemic segmentation contributed significantly to final status ($p = .004$) and the intercept difference between regular and exception words ($p = .017$) in the model of oral reading, holding constant significant effects of reading instruction and initial scores on spelling regular words. For all 80 children, every additional point on the segmentation test in October led to approximately a half-word increase in May scores in oral reading and a

two-tenths-word decrease in the difference in growth rate between regular and exception words.

However, initial status on reading aloud regular and exception words did not contribute significantly to the model of phonemic segmentation, keeping in mind that this analysis was performed on the 55 out of 80 children who scored low enough initially to demonstrate reliable growth rates. When the model of oral reading was reanalyzed for these 55 children, with percentage gain in phonemic segmentation substituted for initial status in phonemic segmentation, the contribution of this percentage gain to the slope of word type was only marginally significant ($p = .099$), controlling for significant effects of reading instruction and initial status on spelling regular words. This contribution was negative, meaning that improvement in segmenting sounds was associated with a smaller difference between the growth rates for regular and exception words.

In sum, these data suggest more of a uni-directional rather than a bi-directional relation between phonemic segmentation and oral reading, supporting the Bradley and Bryant (1983, 1985) position. Early skill in segmentation was predictive of oral reading performance and improvement in segmentation skill was (marginally) predictive of one aspect of oral reading performance. However, early skill in oral reading was not predictive of segmentation performance or growth in segmentation skill.

The skill that did appear to enter into a bi-directional relation with phonemic segmentation was spelling. Initial status on phonemic segmentation contributed significantly to the final status of spelling ($p = .01$) and to the expected differences between regular and exception words ($p = .007$), holding constant significant effects of reading instruction and initial scores on reading aloud regular words. When this spelling model was reanalyzed for the 55 children who scored low enough initially to demonstrate reliable growth in phonemic segmentation, percentage gain in segmentation entered significantly into every stage of the model (i.e., $p = .026$, .033, .024, and .026 for final status, word type, word type x growth rate, and growth rate, respectively), controlling for

other significant effects. Finally, with phonemic segmentation as the outcome measure for these 55 children, initial status in spelling regular words contributed uniquely to final status ($p = .016$) and also contributed to growth rate ($p = .023$), controlling for the significant effect of initial segmentation status.

In summary, early skill in segmentation was predictive of spelling performance and improvement in segmentation skill was predictive of all aspects of spelling performance. In turn, early skill in spelling was predictive of segmentation performance.

Now that we have made a tentative case with these data for a uni-directional relation between phonemic segmentation and oral reading and a bi-directional relation between phonemic segmentation and spelling, we turn to the remaining piece of the triad, the relation between spelling and oral reading. We had reasoned that knowledge of words' spellings would predict accuracy of their readings for children receiving phonics instruction. What we found was that initial skill in spelling regular words predicted final oral readings and initial skill in reading aloud regular words predicted accurate final spellings (at $p < .001$), holding constant significant effects of reading instruction. We also found that higher initial accuracy in spelling and in reading regular words predicted decreases in the different growth rates for regular and exception words, again controlling for the significant effect of reading instruction. The only difference between the two models, and an important one, was that initial scores on reading aloud regular words significantly predicted growth rate in spelling, controlling for significant effects of reading instruction, whereas initial scores on spelling regular words did not significantly predict growth rate in oral reading.

In conclusion, we find some support for Ehri's (1989) claim that knowledge of a word's spelling is relevant to how a word is read. With respect to these data, it is knowing how to correctly spell regular words in the beginning of first grade that predicts improvement in oral reading across the year. This knowledge was predictive for children in both reading methods but only after controlling for the significant effect of reading

instruction on growth rate, an effect which favored phonics instruction. In other words, as Table 3 so clearly points out, phonics children's growth rate for reading aloud regular words was almost twice that of whole word children. Consequently, phonics children's faster accumulation of knowledge about spelling regular words led to earlier recognition of words' correct pronunciations. This kind of snowballing of knowledge is what Stanovich (1986) means by Matthew Effects. In this case, phonics children's instruction in segmenting and blending sounds appeared to help them relate their knowledge of regular word spellings to correct oral readings at a faster rate than whole word children's instruction.

How Reading Instruction Mediates Regularity Effects in Oral Reading

As predicted, all children read and spelled regular words better than exception words and tended to regularize exception words when making errors. However, also as predicted, children receiving whole word instruction did not exhibit regularity effects to the same extent nor at the same rate as children receiving phonics instruction. Reading and spelling errors progressed from nonphonetic to phonetic to accurate responses for all children, but children receiving phonics instruction moved through the progression faster. In fact, when reading aloud exception words, whole word subjects made significantly fewer nonphonetic errors as time passed, but their increase in numbers of phonetic errors was not significant. With respect to accuracy, phonics instruction led to a greater number of words read aloud correctly than whole word instruction did. The phonics children's superior accuracy was most dramatic across time for regular words, but was also apparent for exception words. The negligible improvement whole word children made on reading aloud exception words is particularly disturbing given the additional fact that these children did not significantly increase their production of phonetic errors.

Interpretation of the effect of reading instruction in the repeated measures analysis of oral reading is aided by reference to the HLM model. By comparing the distribution of growth rate estimates for reading aloud exception and regular words (see Figure 2), we

were able to see that children in the phonics group were improving at a faster rate than children in the whole word group, especially those children in the top and bottom quartiles of the distributions. This phonics advantage was true not only for regular words, the type of word on which phonics instruction is focused, but also on exception words, the type of word on which whole word instruction supposedly thrives. By putting individual variation into the error term, the repeated measures technique obscured the steepness of individual phonics children's slopes showing improvement in reading aloud regular words. One consequence of such distortion is that a wait-and-let's-see policy becomes defensible. Yes, this argument claims, average phonics children's decoding skills may be better than whole word children's at the end of grade one, but by the middle of grade two whole word children will catch up. Although the HLM analyses do not justify inferences projected beyond the time frame actually studied, with HLM techniques, individual variation is the focus of the model. Accordingly, HLM results are more indicative of Matthew Effects, whereby the rich get richer in reading and the poor get poorer in reading (Stanovich, 1986). In other words, phonics children's greater rate of improvement in reading aloud regular and exception words in first grade may only multiply the probabilities of enhanced lexical access and enhanced comprehension later on (see Stanovich, Nathan & Zolman, 1988). Of course, whether this holds true beyond grade one remains to be seen.

How Reading Instruction Mediates Word Recognition in a Non-Oral Task

Since regularity effects may be partly an artifact of a reading aloud task, where the assembly of a phonological code is demanded for output, results from the non-oral, word recognition task were of particular interest. As predicted, analysis of errors on exception words in the rime condition showed phonics children attending to medial as well as beginning and ending sounds of words earlier in the year than whole word children. Contrary to prediction, reading instruction was marginally significant (i.e., $p = .04$) in the repeated measures analysis of word recognition and was clearly significant in the HLM analyses of this outcome measure, favoring phonics children not whole word children.

Specifically, reading instruction significantly predicted final status and growth rate in word recognition (at $p < .001$), controlling for the effect of initial age. On average, phonics-instructed children had more correct word identifications in May than whole word-instructed children. Additionally, above average phonics children improved in word identification at a slower rate than their whole word peers, presumably because those at the top have less room to grow on this non-oral measure of word recognition.

In summary, even in a word recognition task that seemingly invites visual analysis skills, the kind of skills emphasized by whole word instruction, the whole word children's performance again lagged behind phonics children's. In the repeated measures analysis, phonics children's superior performance appeared restricted to the increase in correct identifications of exception words between February and May. In the HLM results, however, reading instructional differences in final status and growth rate cut across the linguistic effects of the stimuli, that is, whether targets were regular or exceptional in their spellings and whether alternative words in the list shared onsets or rimes with the target. Finally, by modeling individual growth trajectories, the HLM approach predicted Matthew Effects in this non-oral reading task just as it did in the oral reading task. In this case, the ones who got richer were phonics children and children with high initial scores on recognizing targets in the onset condition, with high initial scores on reading aloud regular words, and with high initial scores on phonemic segmentation.

Conclusion

We remind the reader that in the repeated measures analyses the main effect of reading instruction was significant at $p = .022$ for the oral reading measure and $p = .04$ for the non-oral, word recognition measure. The results that were significant at our criteria of $p < .01$ were interactions of reading instruction with time in the case of spelling and three-way interactions of reading instruction x time x word type in the case of the two measures of reading. However, the case for the escalating superiority of phonics instruction on reading and spelling performance was much clearer in the HLM analyses.

And it is important to remember that IQ (as measured by the PPVT) never entered into these HLM models. That is, these effects were not simply due to superior ability in the phonics children.

Furthermore, examination of the plots of growth rate estimates reveals a startling picture of individual differences within method of reading instruction. On the oral reading test it was children in the phonics group who improved at the more variable rate, especially in the tails of the distribution. On the phonemic segmentation test it was children in the whole word group who had the more variable growth, again, especially in the tails of the distribution. With respect to spelling, whole word children's growth rate, especially on exception words, had greater variability than phonics children's. That is, many whole word children improved dramatically in spelling exception words while others actually had negative growth predicted. In fact, three children in the whole word group were dropped from the analysis because they spelled no words correctly across the entire year.

The impressive gain in accurate spellings of exception words for many whole word children was possibly due to the more phonetic nature of their spelling instruction. Phonics children received traditional, visually-oriented, instructional techniques of spelling-to-dictation and practice in writing, correcting, and rewriting words. In contrast, whole word children practiced segmenting projected words into syllables, then phonemes, before writing the word from memory. Such direct instruction in segmentation would provide a useful strategy for success in this study's spelling-to-dictation test. That the payoff for this segmentation strategy was particularly apparent for words with exceptional spelling patterns is further confirmation of the utility of invented spellings to the construction of correct spellings. All children produced such "creative" errors and the choice of letters in these errors increasingly reflected alphabetic understanding across the first grade year, allowing some whole word children to move rapidly to correct renditions of the orthography. Then again, some whole word children clearly did not profit from the segmentation training embedded in their spelling instruction. Nevertheless, the potential

for enhancing alphabetic understanding by combining reading and spelling instruction is obvious. Ehri's (1989) claim for the relevance of spelling knowledge to reading performance would probably be demonstrated in such a combined approach. Of course writing approaches to reading are, in fact, doing this very thing. But for many five and six year olds the motor demands of writing may disrupt the transfer of alphabetic understanding from spelling to reading. Yet it may well be the act of writing itself that is crucial to grasping phonemic awareness in graphic form (Cunningham & Stanovich, in press).

From our perspective the next step is to further examine the effects of growth in segmentation skill where ceiling effects are not present in the instrument. Assuming the present findings would still hold, the next step would be to intervene with training in grapheme-phoneme correspondence rules early enough in first grade to ward off the accelerating cycle of Matthew Effects. We recently completed six weeks of onset-rime training in these same whole word classrooms (Haskell, 1989), and results are promising. Additionally, we are investigating the performance of children who exhibited little to no growth in the present investigation so as to facilitate early identification of children at risk for reading failure.

Footnote

1. Technically these data could be viewed as three level: time nested within subjects and subjects nested within classrooms. For the purposes of these analyses, we were unable to treat this second level of nesting because of the limited number of classrooms. We included classroom as a potential predictor in all between unit models, but in no case did classroom contribute significantly to prediction.

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Table 1

Sample Characteristics

Dependent Variable	Reading Instruction: Phonics (N=40) Mean	Range	Whole Word (N=40) Mean	Range
Age (in months)	79.80	71-90	81.85	75-94
Gates-MacGinitie (raw scores)	37.47*	16-51	35.12**	19-51
PPVT (raw scores)	80.32+	60-111	77.05++	55-100

* Grade level equivalent of 1.5
** Grade level equivalent of 1.4
\+ Deviation IQ equivalent of 107
++ Deviation IQ equivalent of 100

Table 2

Mean Number Correct and Standard Deviations of Tests at Three Observation Points for Two Reading Methods

Test/Time	Whole Word Method				Phonics Method			
	Regular*		Exception		Regular		Exception	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Spelling								
October	6.47	6.56	.45	1.06	5.85	4.39	.45	.78
February	14.15	9.16	1.85	1.89	17.67	7.01	1.97	1.61
May	18.30	10.20	3.10	2.95	23.95	6.55	5.20	3.23
Oral Reading								
October	12.05	11.17	3.37	3.36	12.70	8.84	3.97	2.83
February	19.27	12.98	6.20	4.08	26.42	9.55	7.77	4.20
May	24.10	12.84	6.95	4.40	31.82	8.33	10.10	3.66
Recognition Reading								
October								
Onset	5.97	2.72	2.95	2.19	6.52	2.41	3.40	2.20
Rime	4.80	2.31	3.05	1.36	5.17	2.31	3.25	1.63
Mean	5.38		3.00		5.85		3.32	
February								
Onset	7.22	2.39	4.77	2.98	8.35	1.92	5.52	2.88
Rime	5.60	2.60	4.02	2.12	6.90	2.20	4.07	1.33
Mean	6.41		4.39		7.62		4.80	
May								
Onset	7.82	2.64	5.40	3.13	8.85	1.82	7.15	2.31
Rime	6.80	2.73	4.17	1.95	7.95	2.50	5.22	1.79
Mean	7.31		4.78		8.40		6.19	
		Mean	SD		Mean	SD		
Phonemic Segmentation								
October		6.57	3.86		7.45	3.40		
February		8.72	2.78		8.72	3.02		
May		9.75	2.44		10.20	2.44		

*There were 40 regular words and 20 exception words. However, only 20 regular words were analyzed in the recognition reading test.

Table 3

Coefficients of the individual growth model for spelling as a function of word type and reading instruction

Effects	Exception Words		Regular Words	
	Whole Word	Phonics	Whole Word	Phonics
Intercept	.484	2.008	9.516	14.712
Initial phonemic segmentation status	.038	.038	.318	.318
Initial oral reading status/Regulars	.194	.194	.584	.584
Initial oral reading status/Regulars x Time	.023	.023	.023	.023
Time	.100	.370	1.424	2.314

NOTE. Phonemic segmentation is significant at $p < .01$. All other effects are significant at $p < .001$.

Table 4

Estimated variance components (random effects)

Dependent Variable	Estimated Parameter Variance	df	X^2	Reliability[a]
Spelling[b]				
Final status	9.7529	73	487.90*	.86
Word Type	4.7081	73	256.69*	.75
Word type x time	.0918	75	128.46*	.53
Growth rate	.1795	74	206.80*	.69
Oral reading				
Final status	24.8398	76	878.27*	.91
Word type	8.9007	76	354.88*	.79
Word type x time	.1632	78	162.32*	.57
Growth rate	.3452	78	284.88*	.74
Word recognition				
Final status	1.0902	75	289.09*	.74
Word type	.2034	79	177.54*	.55
Word part	.1315	78	130.94*	.45
Growth rate	.0196	73	121.48*	.50
Phonemic Segmentation[c]				
Final status	5.0091	53	517.48*	.90
Growth rate	.0882	52	195.05*	.75

[a]Proportion of variance explained

[b]Spelling values are based on only 77 out of 80 subjects that had adequate data for computation.

[c]Analysis of this variable was performed on the 55 out of 80 subjects who demonstrated reliable growth rates.

*p<.001

Table 5

Coefficients of the individual growth model for oral reading as a function of word type and reading instruction

	Exception Words		Regular Words	
Effects	Whole Word	Phonics	Whole Word	Phonics
Intercept	3.38	6.44	12.36	21.26
Initial phonemic segmentation status	.189	.189	.585	.585
Initial spelling status/Regulars	.407	.407	1.239	1.239
Time	.517	.875	1.723	2.765

NOTE: $p = .107$ for the effect of phonemic segmentation and $p = .005$ for the effect of reading instruction on the intercept difference between regular and exception words. All other effects are significant at $p < .001$

Table 6

Coefficients of the individual growth models for word recognition as a function of word type and word part

	Whole Word				Phonics			
	Exception		Regular		Exception		Regular	
Effects	Onset	Rime	Onset	Rime	Onset	Rime	Onset	Rime
Intercept	9.302	8.87	11.716	11.284	10.056	9.624	12.470	12.038
Initial age	-.078	-.078	-.078	-.078	-.078	-.078	-.078	-.078
Initial oral reading/Regular	.150	.098	.150	.098	.150	.098	.150	.098
Initial phonemic segmentation	.114	.114	.114	.114	.114	.114	.114	.114
Time	1.19	1.19	1.19	1.19	-1.19	-1.19	-1.19	-1.19
Initial age	-.009	-.009	-.009	-.009	-.009	-.009	-.009	-.009
Init. onset-regular	-.045	-.045	-.045	-.045	-.045	-.045	-.045	-.045
Init. onset-exception	-.052	-.052	-.052	-.052	-.052	-.052	-.052	-.052
Init. oral reading/ Regulars	.015	.015	.015	.015	.015	.015	.015	.015
Init. phonemic/ segmentation	.016	.016	.016	.016	.016	.016	.016	.016

NOTE: Coefficients for the same effect that differ across word type, word part, or reading instruction are significant at $p < .01$.

Figure Captions

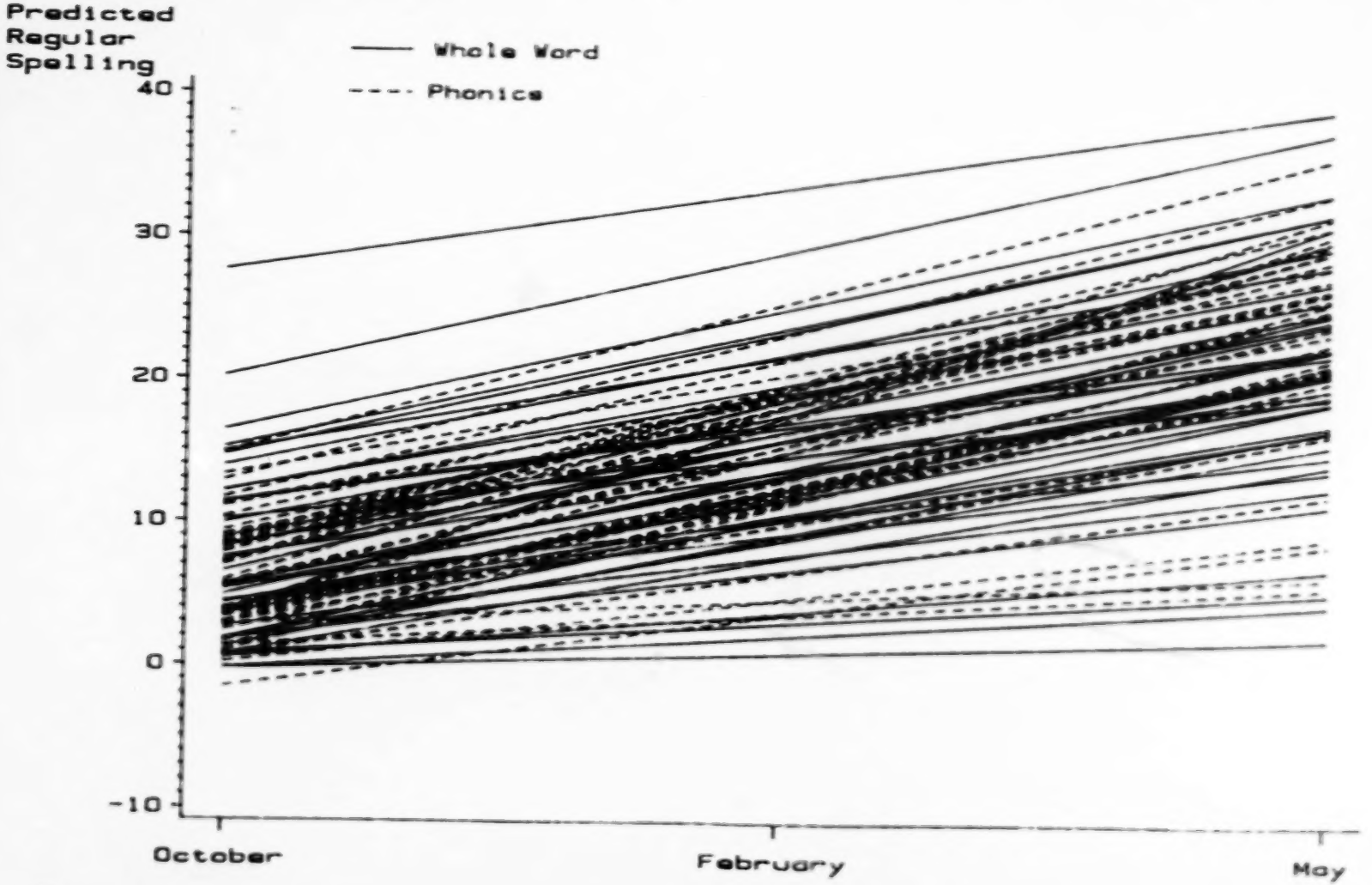
Figure 1 Comparison of estimated individual growth in spelling of regular and exception words during grade 1.

Figure 2 Comparison of distributions of growth rate estimates for oral reading as a function of word type and reading instruction.

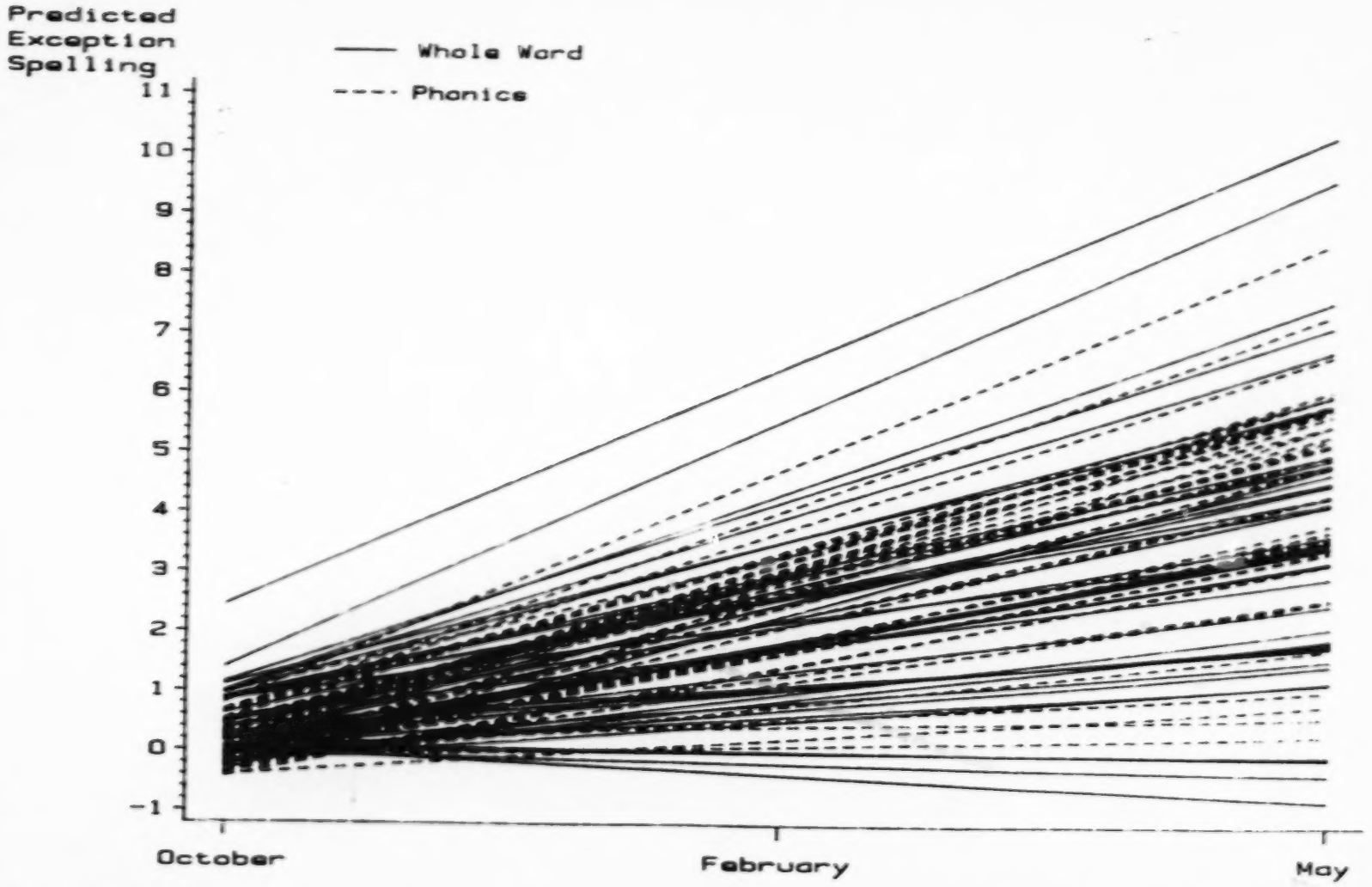
Figure 3 Change in phonemic segmentation from October to May as a function of initial score.

Figure 4 Comparison of distributions of growth rate estimates for phonemic segmentation as a function of reading instruction.

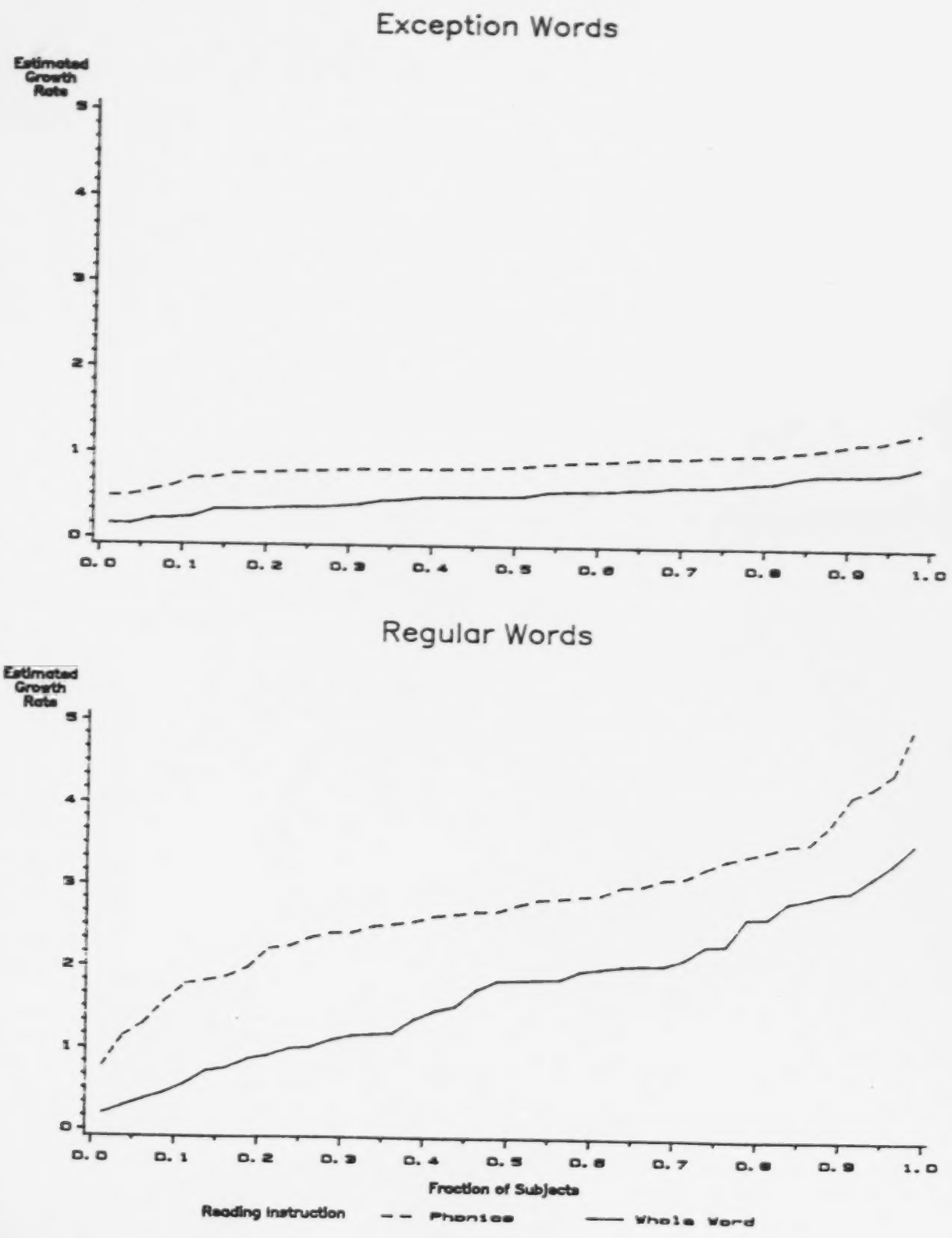
Comparison of Estimated Individual Growth in Spelling of Regular Words During Grade 1



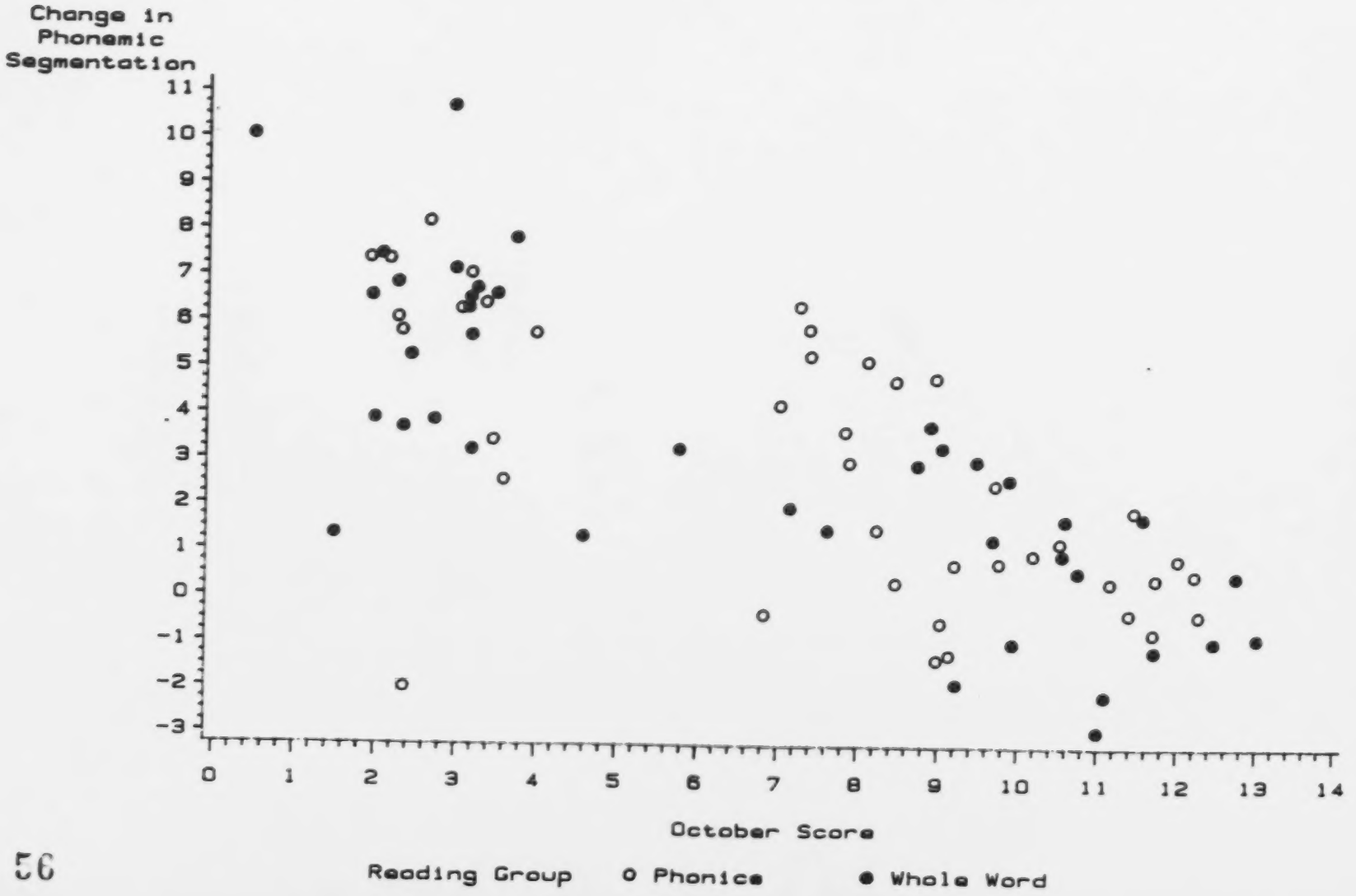
Comparison of Estimated Individual Growth in Spelling of Exception Words During Grade 1



Comparison of Distributions of Growth Rate Estimates for Oral Reading
as a function of Word Type and Reading Instruction



Change in Phonemic Segmentation From October to May as a Function of Initial Score



Comparison of Distributions of Growth Rate Estimates for Phonemic Segmentation as a function of Reading Instruction